

***Nippostrongylus marhaeniae* sp. n. and Other Nematodes Collected from *Rattus* cf. *morotaiensis* in North Halmahera, Molucca Islands, Indonesia**

HIDEO HASEGAWA^{1,3} AND SYAFRUDDIN²

¹ Department of Parasitology, School of Medicine, University of the Ryukyus, Nishihara, Okinawa 903-01, Japan and

² Department of Parasitology, Faculty of Medicine, Hasanuddin University, Ujung Pandang, Indonesia

ABSTRACT: *Nippostrongylus marhaeniae* sp. n., 2 *Odilia* spp., *Orientostrongylus* sp., *Strongyloides ratti*, and *Mastophorus muris* were collected from *Rattus* cf. *morotaiensis* from Halmahera Island, North Moluccas, Indonesia. *Nippostrongylus marhaeniae* resembles *N. magnus* and *N. typicus* of Australian rats in the bursal structure but is readily distinguished by having only 12 ridges of synlophus in midbody of both sexes and in that the tips of spicules are not recurved strongly. Species of *Odilia* were first recorded outside of New Guinea-Australian region, and 1 of the present species closely resembles *O. mackerrasae* from the Australian rat by having intermittent ridges in the ventral side. Presence of the trichostrongyloids closely related to the Australian representatives suggests that these nematodes were introduced by some rats from the New Guinea-Australian region and have been maintained within the endemic rat community on Halmahera Island.

KEY WORDS: *Nippostrongylus marhaeniae* sp. n., nematodes, *Rattus* cf. *morotaiensis*, Halmahera Island, Indonesia, systematics, zoogeography.

Rattus morotaiensis Kellogg, 1945, is distributed in North Moluccas, Indonesia (type locality: Morotai Island) (Musser and Carleton, 1993). Because only limited examples have been collected, the biology of this endemic rat has not been adequately elucidated. In 1993, we had a chance to collect murines for parasitological survey on Halmahera Island, located just south of Morotai Island. One individual of *R. cf. morotaiensis* was incidentally obtained, and its parasitological examination revealed 6 nematode species, of which 4 are trichostrongyloids of systematic interest. This paper deals with these nematodes with special reference to the zoogeography of the host and parasites.

Materials and Methods

The rat, captured by a domestic cat in the nearby forest of Kai village, Kao District, North Halmahera, Moluccas, Indonesia, was examined. Its viscera were fixed with 10% formalin solution on the same day of capture, and then parasites were collected under a stereomicroscope. Collected nematodes were rinsed in 70% ethanol solution, cleared in glycerol-alcohol solution, and mounted with 50% glycerol solution. Freehand cross-sections were made for observation of the synlophus of the trichostrongyloids. Figures were made with the aid of a drawing tube. Given measurements, in micrometers unless otherwise stated, are for the holotype male and the allotype female, followed in parentheses by the range of paratype males and females. The terminology of the synlophus follows Durette-Desset (1983).

Nematode specimens are deposited in the United States National Museum Helminthological Collection (USNM Helm. Coll.), Beltsville, Maryland, U.S.A. The stuffed skin and skull specimen of the host are deposited in the American Museum of Natural History, New York, U.S.A., AMNH267681.

Results

Four nematode species belonging to the subfamily Nippostrongylinae (Trichostrongyloidea: Heligmonellidae) were found in the small intestine as described later. *Strongyloides ratti* Sandground, 1925 (Rhabditoidea: Strongyloididae) (2 parasitic females: USNM Helm. Coll. No. 84315), and *Mastophorus muris* (Gmelin, 1790) (Spiruroidea: Spirocercidae) (3 males and 9 females: USNM Helm. Coll. No. 84316) were also collected from the small intestine and the stomach, respectively.

***Nippostrongylus marhaeniae* sp. n.**

(Trichostrongyloidea: Heligmonellidae:

Nippostrongylinae)

(Figs. 1-13)

GENERAL: Small red worms, forming sinistral tight or flat coils with ventral side located inside. Anterior end with cephalic vesicle (Figs. 1, 2). Mouth triangular (Fig. 1). Four large cephalic papillae, 6 small labial papillae and amphids present (Fig. 1). Cuticle finely striated. Synlophus well developed with pointed ridges, commencing immediately posterior to cephalic vesicle and ending slightly anterior to bursa in male,

³ Corresponding author.

and at vulval level in female (Figs. 2, 4, 13). In midbody of both sexes 12 ridges present, carene of type A supported by hypertrophied left lateral ridge present; axis of orientation of ridges passing through ventral-right and dorsal-left sides, inclined about 45° from sagittal axis; 2 ridges in right to right-dorsal field and 3 ventral-left ridges well developed, 2 right-ventral ridges less developed; midventral to ventral-right portion devoid of ridges (Figs. 3, 12). Esophagus club-shaped (Fig. 2). Nerve ring posterior to midesophagus, excretory pore at midpoint between nerve ring and posterior end of esophagus, and deirids at same level or slightly posterior to excretory pore (Fig. 2).

MALE (holotype and 3 paratypes): Length 3.61 (3.20–3.88) mm, width at midbody 104 (94–112). Cephalic vesicle 66 (58–74) long by 36 (35–42) wide. Nerve ring 203 (154–193), excretory pore 268 (245–310), and deirids 288 (245–313) from cephalic end. Esophagus 320 (315–353) long and 26 (24–26) wide near posterior end. Bursa asymmetrical, right lobe larger than left lobe; bursal rays except posterolateral and externodorsal rays in right lobe thicker than in left lobe (Figs. 5, 8). Right lobe: ventral rays widely divergent; lateroventral ray slightly longer than ventroventral ray; externolateral and mediolateral rays thick, divergent distally; posterolateral ray short, small, arising from base of mediolateral ray, divergent widely from other laterals; externodorsal ray thin, arising from proximal half of trunk of dorsal ray (Figs. 5, 8). Left lobe: ventral rays moderately divergent, ventroventral ray slightly shorter than lateroventral ray; externolateral ray attached lateroventral ray along almost whole length, slightly shorter than lateroventral ray; mediolateral ray shortest among laterals, directed lateroventrally; posterolateral ray thickest among laterals, directed posterolaterally; externodorsal ray arising from distal half of trunk of dorsal ray, much thicker than right externodorsal ray (Figs. 5, 8). Dorsal ray with thick trunk, divided at distal 1/3 into 2 branches, each of which again divided into 2 offshoots. Outer offshoots longer than inner offshoots, directing posterolaterally; each inner offshoot provided with 2 papillae apically (Figs. 5, 7). Genital cone protruded prominently, with 1 pair of conical papillae apically; anterior lip of cloaca less protruded, provided with 1 papilla (Fig. 6). Spicules equal in length, alate, joined and slightly twisted distally (Fig. 9). Left spicule slightly thickened distally forming round tip (Fig.

10), and right spicule tapering distally forming pointed tip (Fig. 11). Spicule length 388 (335–385) (corresponding to 9.6–10.7% of worm length). Gubernaculum boat-shaped, 21 (21–22) long (Fig. 4).

FEMALE (allotype and 1 complete and 1 incomplete paratype): Length 4.13 (3.92) mm, width at midbody 109 (88). Cephalic vesicle 53 (56) long by 43 (53) wide. Nerve ring 144 (177), excretory pore 208 (270), and deirids 214 (273) from cephalic end. Esophagus 269 (310) long and 24 (32) wide near posterior end. Body narrowed at vulval level and postvulval body bent ventrally strongly (Fig. 13). Vulva 84 (68–96) and anus 33 (26–29) from caudal end (Fig. 13). Vagina vera 24 (32–50) long, forming diverticulum dorsally; vestibule narrowed distally, 80 (72–83) long; sphincter 31 (24–25) long; infundibulum 125 (64–128) long (Fig. 13). Cuticle between vulva and anus distended (Fig. 13). Tail conical (Fig. 13). Eggs ellipsoidal, thin-shelled, containing morula to tadpole-stage embryos, and 53–56 × 30–34.

TYPE HOST: *Rattus cf. morotaiensis* (Muridae: Murinae).

SITE: Small intestine.

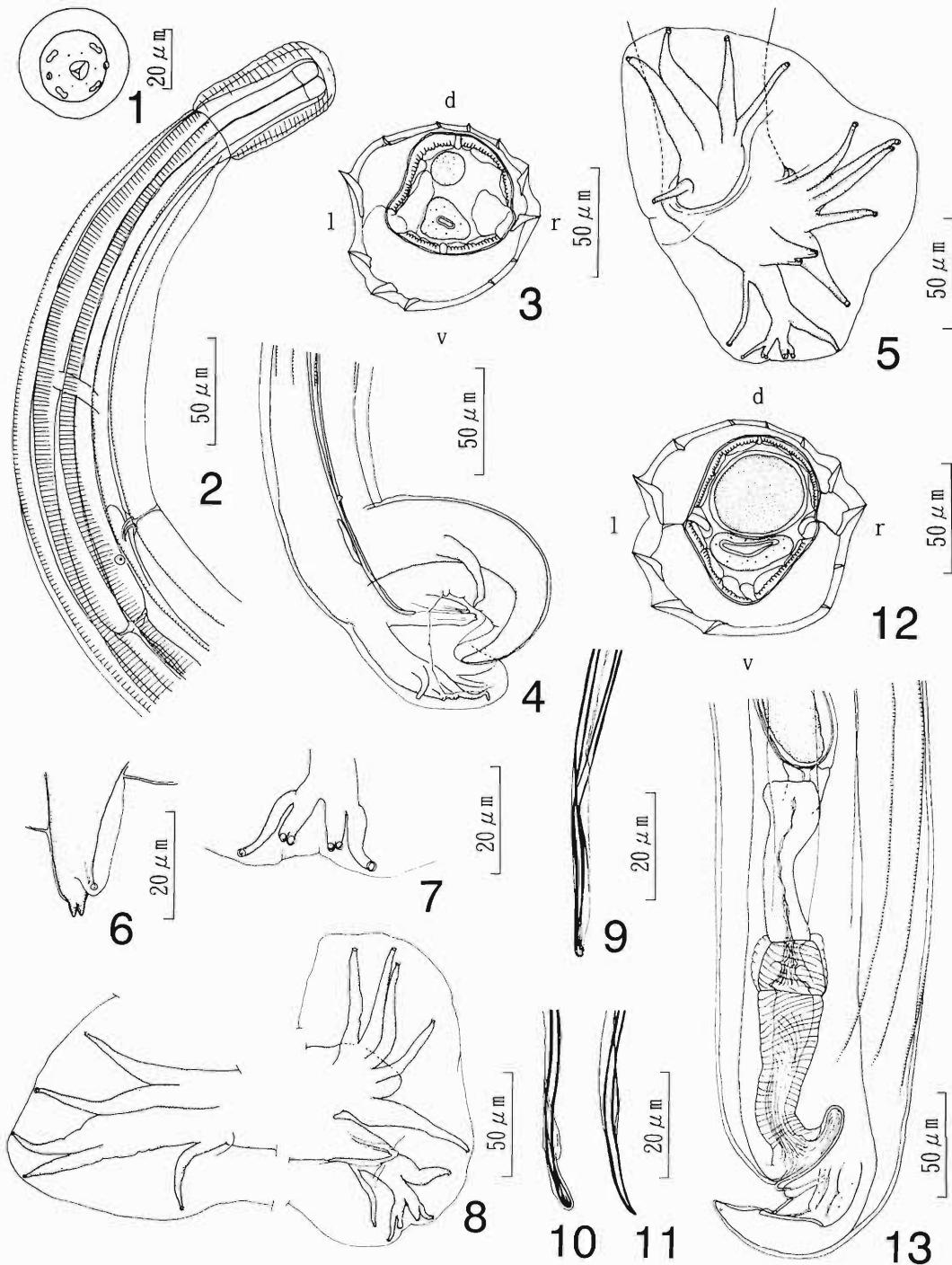
TYPE LOCALITY: Kai (1°32'N, 127°48'E; 100 m elevation), North Halmahera, Indonesia.

DATE OF COLLECTION: 11 July 1993.

ETYMOLOGY: Species name is dedicated to Dr. Marhaeni Hasan, director of the Kao Health Center, to whom we are greatly indebted for the survey.

TYPE SPECIMENS: USNM Helm. Coll. No. 84317 (holotype and allotype) and 84318 (3 male and 2 female paratypes).

REMARKS: The present species has every morphological characteristic of the genus *Nippostrongylus* Lane, 1923, although its synlophus consists of only 12 ridges (Durette-Desset, 1970a, 1983). *Nippostrongylus marhaeniae* resembles *Nippostrongylus typicus* (Mawson, 1961) and *Nippostrongylus magnus* (Mawson, 1961), both of which have been known from Australian murines, in that the left externodorsal ray is thicker and arising from a more distal level of the trunk of the dorsal ray than the right one (Mawson, 1961; Durette-Desset, 1969; Beveridge and Durette-Desset, 1992). Specimens of *N. marhaeniae* are easily distinguished by this character from *Nippostrongylus brasiliensis* (Travassos, 1914), *Nippostrongylus rysavyi* (Erhardová, 1959), *Nippostrongylus rauschi* Chabaud and Dasset, 1966,



Figures 1–13. *Nippostrongylus marhaeniae* sp. n. from *Rattus* cf. *morotaensis* from Halmahera Island, North Moluccas, Indonesia. 1. Cephalic extremity of male, apical view. 2. Anterior part of holotype, right lateral view. 3. Cross-section of male through midbody. 4. Posterior part of holotype, right lateral view. 5. Bursa copulatrix of paratype, ventral oblique view. 6. Genital cone, subventral view. 7. Distal end of dorsal ray, ventral view. 8. Bursa copulatrix dissected, ventral view. 9. Distal ends of spicules. 10. Distal end of left spicule dissected. 11. Distal end of right spicule dissected. 12. Cross-section of female through midbody. 13. Posterior part of allotype, left lateral view. Abbreviations: d = dorsal, l = left, r = right, v = ventral.

Nippostrongylus djumachani (Tenora, 1969), *Nippostrongylus witenbergi* Greenberg, 1972, and *Nippostrongylus* sp. of Hasegawa (1990) (Erhardová, 1959; Mawson, 1961; Chabaud and Desset, 1966; Durette-Desset, 1969, 1970a; Tenora, 1969; Greenberg, 1972; Hasegawa, 1990). *Nippostrongylus typicus* and *N. magnus* have a strongly recurved distal end of the spicule, being readily distinguished from the present species (Mawson, 1961; Beveridge and Durette-Desset, 1992).

Odilia sp. 1

(Trichostrongyloidea: Heligmonellidae:
Nippostrongylinae)

HOST: *Rattus* cf. *morotaiensis* (Muridae: Murinae).

SITE: Small intestine.

LOCALITY: Kai (1°32'N, 127°48'E; 100 m elevation), North Halmahera, Indonesia.

DATE OF COLLECTION: 11 July 1993.

SPECIMENS: USNM Helm. Coll. No. 84319 (1 male and 3 females).

REMARKS: The present specimens belong to the genus *Odilia* Durette-Desset, 1973 (syn. *Austrostrongylus* sensu Durette-Desset, 1971, nec Chandler 1927), in that the left lateral ridge of the synlophus is hypertrophied with the adjacent dorsal one supporting the carene of type A, the bursa copulatrix is asymmetrical, the dorsal ray is divided in its basal half, and the externodorsal rays are of similar size (Durette-Desset, 1971, 1973, 1983). By having intermittent ridges in the ventral half of the body, this species is especially close to *Odilia mackerrasae* (Mawson, 1961) from *Melomys cervinipes*, *Melomys lutillus*, *Melomys* sp., and *Uromys caudimaculatus* of North Australia (Mawson, 1961; Durette-Desset, 1969) and from *Rattus fuscipes* of South Australia (Obendorf, 1979). It may be distinguished from *O. mackerrasae* by having shorter spicules and a longer esophagus and by lacking a gubernaculum (Mawson, 1961). However, proposal of a new species is withheld because only a small number of the worms was obtained.

Odilia sp. 2

(Trichostrongyloidea: Heligmonellidae:
Nippostrongylinae)

HOST: *Rattus* cf. *morotaiensis* (Muridae: Murinae).

SITE: Small intestine.

LOCALITY: Kai (1°32'N, 127°48'E; 100 m elevation), North Halmahera, Indonesia.

DATE OF COLLECTION: 11 July 1993.

SPECIMEN: USNM Helm. Coll. No. 84320 (1 female).

REMARKS: Only 1 female was collected. Although a male was not collected, it is possible to classify this species in the genus *Odilia* by the typical arrangement of synlophus ridges (Durette-Desset, 1971, 1983). The present female was a coparasite of the former species but is easily distinguished by the fact that the synlophus ridges are all continuous and the right lateral ridge is quite small. The synlophus of the present female resembles that of *Odilia brachybursa* (Mawson, 1961) from *M. cervinipes* of Australia by having 15 ridges in midbody (Mawson, 1961; Durette-Desset, 1969).

Orientostrongylus sp.

(Trichostrongyloidea: Heligmonellidae:
Nippostrongylinae)

HOST: *Rattus* cf. *morotaiensis* (Muridae: Murinae).

SITE: Small intestine.

LOCALITY: Kai (1°32'N, 127°48'E; 100 m elevation), North Halmahera, Indonesia.

DATE OF COLLECTION: 11 July 1993.

SPECIMENS: USNM Helm. Coll. No. 84321 (3 males and 1 female).

REMARKS: The present material resembles *Orientostrongylus tenorai* Durette-Desset, 1970, which has been known from various murines in the areas from Afghanistan to Taiwan (Durette-Desset, 1970b; Ohbayashi and Kamiya, 1980; Ow Yang et al., 1983; Hasegawa, 1990; Hasegawa et al., 1994), and also from *Rattus rattus* and *Rattus exulans* on Halmahera Island (Hasegawa and Syafruddin, 1995). It is distinguished from the examples of *O. tenorai* from these rats on Halmahera Island by having a much thicker body and longer spicules. However, more comparative study, especially on the host-dependent variations, is necessary to conclude whether or not it is conspecific with *O. tenorai*.

Discussion

The endemic murines of the Moluccas have been considered to be allied with those on New Guinea and its offshore islands, and *R. morotaiensis* is believed to be closely related to native *Rattus* of New Guinea (Musser, 1981; Musser and Carleton, 1993). The present nematode fau-

na also contains the species with close morphological resemblance to the New Guinea–Australian representatives. *Nippostrongylus marhaeniae* shares same bursal characteristics with *N. typicus* and *N. magnus* from Australian *Melomys*. The genus *Odilia* has been recorded only in Australia and New Guinea (Irian Jaya) (Durette-Desset, 1983; Hasegawa and Syafruddin, 1994). The presence of the *Odilia* species with intermittent synlophic ridges in the ventral cuticle on Halmahera Island is of special interest because its most allied species, *O. mackerrasae*, has been recorded from *Melomys*, which is distributed in Australia, New Guinea, and North Moluccas (Musser and Carleton, 1993). It is therefore probable that these nematodes were introduced by some endemic rats from New Guinea to Halmahera Island and have been maintained within the endemic murine populations on this island.

The trichostrongyloid fauna of *R. cf. morotaiensis* of Halmahera seems to be critically different from that of *R. rattus* and *R. exulans* on this island: only *N. brasiliensis* and *O. tenorai* were detected from the latter 2 species (Hasegawa and Syafruddin, 1995). The dispersal of these 2 murines in the Pacific islands is considered to have been facilitated by humans (cf. Musser and Carleton, 1993). *Nippostrongylus brasiliensis* is a cosmopolitan parasite of *R. rattus* and *Rattus norvegicus*, and *O. tenorai* is also a common nematode of the rats in Southeast and East Asia (cf. Ohbayashi and Kamiya, 1980; Ow Yang et al., 1983; Hasegawa et al., 1994). Thus, it is presumed that these 2 trichostrongyloids have been introduced to Halmahera by the commensal rats (Hasegawa and Syafruddin, 1995). The difference in trichostrongyloid fauna between the *R. cf. morotaiensis* and the commensal rats may be attributed to the host specificity of the parasites and/or the habitat segregation of the hosts.

Acknowledgments

Special thanks are rendered to Dr. G. G. Musser for his kind help in identifying the host rodents and criticism on the manuscript and to Dr. J. Araki and Dr. I. Beveridge for their kindness in supplying copies of related papers. This study was carried out under the regulation of LIPI (Indonesian Institute of Sciences) and was financially supported by a grant-in-aid from the Ministry of Education, Science and Culture, Japanese Government, No. 03041065.

Literature Cited

Beveridge, I., and M. C. Durette-Desset. 1992. The morphology of *Nippostrongylus magnus*, a parasite of native Australian rodents. *Transactions of the Royal Society of South Australia* 116:109–115.

Chabaud, A. G., and M. C. Desset. 1966. *Nippostrongylus rauschi* n. sp. Nématode parasite de Dermoptères et considérations sur *N. brasiliensis* parasite cosmopolite des Rats domestiques. *Annales de Parasitologie Humaine et Comparée* 41: 243–249.

Durette-Desset, M. C. 1969. Les systèmes d'arêtes cuticulaires chez les Nématodes Héligmosomes parasites de Muridés australiens. *Annales de Parasitologie Humaine et Comparée* 44:733–747.

—. 1970a. Le genre *Nippostrongylus* Lane, 1923, (Nématode—Héligmosomatidé). *Annales de Parasitologie Humaine et Comparée* 45:815–821.

—. 1970b. Caractères primitifs de certains Nématodes Héligmosomes parasites de Muridés et de Cricétidés orientaux. Définition d'*Orientostrongylus* n. gen. *Annales de Parasitologie Humaine et Comparée* 45:829–837.

—. 1971. Essai de classification des Nématodes Héligmosomes. Corrélations avec la paléobiogéographie des Hôtes. *Mémoires du Muséum National d'Histoire Naturelle, Série A, Zoologie* 49: 1–126.

—. 1973. Note rectificative sur le genre *Astrostrongylus* (Nématode). *Annales de Parasitologie Humaine et Comparée* 48:517–518.

—. 1983. Keys to genera of the superfamily Trichostrongyoidea. In R. C. Anderson and A. G. Chabaud, eds. *CIH Keys to the Nematode Parasites of Vertebrates*. No. 10. Commonwealth Agricultural Bureaux, Farnham Royal, Buckinghamshire. 86 pp.

Erhardová, B. 1959. *Oswaldonema rysavyi* n. sp. und *Vianella chinensis* n. sp. (Nematoda; Heligmosomatidae) bei chinesischen Nagern. *Československá Parasitologie* 6:93–96.

Greenberg, Z. 1972. Helminths of birds and mammals from Israel. IV. Helminths from *Nesokia indica* Gray and Hardwicke, 1832 (Rodentia: Muridae). *Israel Journal of Zoology* 21:63–70.

Hasegawa, H. 1990. Nematodes of the family Heliemonellidae (Trichostrongyoidea) collected from rodents of the Ryukyu Archipelago and Taiwan. *Journal of Parasitology* 76:470–480.

—, J. Kobayashi, and M. Otsuru. 1994. Helminth parasites collected from *Rattus rattus* on Lanyu, Taiwan. *Journal of the Helminthological Society of Washington* 61:95–102.

—, and Syafruddin. 1994. *Odilia mallomys* sp. n. (Nematoda: Heliemonellidae) from *Mallomys rothschildi weylandi* (Rodentia: Muridae) of Irian Jaya, Indonesia. *Journal of the Helminthological Society of Washington* 61:208–214.

—, and —. 1995. Nematode fauna of two sympatric rats, *Rattus rattus* and *Rattus exulans*, in Kao District, Halmahera Island, Indonesia. *Journal of the Helminthological Society of Washington* 62:27–31.

Mawson, P. M. 1961. Trichostrongyles from rodents in Queensland, with comments on the genus *Lon-*

gistriata (Nematoda: Heligmosomatidae). Australian Journal of Zoology 9:791-826.

Musser, G. G. 1981. The giant rat of Flores and its relatives east of Borneo and Bali. Bulletin of the American Museum of Natural History 169:62-176.

—, and D. Carleton. 1993. Family Muridae. Pages 501-755 in D. E. Wilson and D. A. M. Reeder, eds. Mammal Species of the World. A Taxonomical and Geographic Reference, 2nd ed. Smithsonian Institution Press, Washington, D.C., and London.

Obendorf, D. L. 1979. The helminth parasites of *Rattus fuscipes* (Waterhouse) from Victoria, including description of two new nematode species. Australian Journal of Zoology 27:867-879.

Ohbayashi, M., and M. Kamiya. 1980. Studies on the parasite fauna of Thailand II. Three nematode species of the genus *Orientostrongylus* Durette-Desset, 1970. Japanese Journal of Veterinary Research 28:7-11.

Ow Yang, C. K., M. C. Durette-Desset, and M. Ohbayashi. 1983. Sur les Nématodes parasites de Rongeurs de Malaisie. II. Les Trichostrongyloidea. Annales de Parasitologie Humaine et Comparée 58:467-492.

Tenora, F. 1969. Parasitic nematodes of certain rodents from Afghanistan. Vestnik Ceskoslovenske Spolecnosti Zoologicke 33:174-192.

Editor's Acknowledgment

In addition to the members of the Editorial Board, I would like to thank the following persons for providing their valuable help and insights in reviewing manuscripts for the *Journal*: David Abraham, Alexander D. W. Acholonu, Martin L. Adamson, John M. Aho, Ruth Ainsworth, John Aliff, Omar M. Amin, J. Richard Arthur, Carter T. Atkinson, Odile Bain, Laura Rickard Ballweber, Cheryl M. Bartlett, Frederick W. Beckerdite, Jeffrey W. Bier, Richard L. Buckner, Charles R. Bursey, Tony A. Charleston, James R. Coggins, William H. Coil, David K. Cone, Michael J. Coyne, Amy E. Crews-Oyen, John L. Crites, Murray D. Dailey, C. Davids, Sherwin S. Desser, Tommy T. Dunagan, Marie Claude Durett-Desset, William G. Dyer, Eugene W. Foor, John C. Frandsen, Bernard Fried, Shin-ichiro Fukumoto, Scott L. Gardner, Louis Gasbarre, Linda M. Gibbons, Timothy Goater, Stephen R. Goldberg, John H. Greve, Harry W. Huizinga, Arthur A. Johnson, James E. Joy, Frank Katz, Kevin R. Kazacos, Delane C. Kritsky, Jeffery M. Lotz, Eugene T. Lyons, David J. Marcogliese, Chris T. McAllister, Larry R. McDougald, Patrick M. Muzzall, Haig H. Najarian, Thomas C. Orihel, Eric A. Ottesen, Sharon Patton, Thomas R. Platt, George Poinar, Anne Prestwood, Roger K. Pritchard, J. A. Raga, Wesley L. Shoop, Mark Siddall, Jeurel Singleton, Grover C. Smart, Jr., Dale A. Smith, Clarence A. Speer, Bert E. Stromberg, Horst Taraschewski, Hugh M. Turner, Jerome Vanderberg, Claude Vaucher, William J. Wardle, Ernest H. Williams, and Darwin D. Witrock.

Sherman S. Hendrix, Editor